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NURSE PLANTING SELECT COTTON SEED.

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THE WASTE OF SELECT COTTON SEED.

How to avoid waste of select cotton seed is a problem confronting every cotton breeder. In order to improve varieties and to maintain select stocks on the highest plane of superiority it is necessary to increase rapidly the best progenies. A relatively slow increase is all that is possible if the usual methods of planting are employed. The waste of valuable seed may prove to be a distinct loss not only to the breeder but to the cotton industry as well. If the waste of seed could be avoided, superior selections of cotton could be established in cultivation one, two, or more years earlier than is now considered possible.

The usual methods of increasing select cotton seed are wasteful in several ways. Though differing somewhat in detail, the main steps are essentially the same in all methods that have come to the writer's attention. The seeds of a select plant are planted first in hills in what is called a progeny row. Only one plant in each hill usually is desired, but it is customary to plant five to eight or more seeds. This is held to be necessary in order to insure a stand. Perfect germination is hardly to be expected, and many of the young seedlings do not survive. A single seedling may be unable to break through if the surface becomes crusted, but several seedlings by combined effort can push out. Under favorable conditions it would not be necessary to plant so many seeds in a hill, but such conditions can not be foretold and hence enough seed must be planted to secure a stand in an unfavorable season.

The natural result of a heavy rate of planting is a thick stand, in the reduction of which it frequently becomes necessary to destroy

50 to 75 per cent of the plants. To thin out large numbers of surplus plants, each of which probably would be capable of producing practically as many bolls as any of the plants left in the row, is extremely wasteful when the potential value of every seed that could be produced is considered.

The planting of so many cotton seeds in a hill has still another disadvantage from the standpoint of increasing valuable selections. The supply of seed when planted in the usual way often does not permit planting in more than one place, and the destruction of that planting, resulting from cold, hail, or any other cause, may mean the total loss of the progeny. A method making possible duplicate or triplicate plantings would reduce that danger of loss and at the same time afford an opportunity for studying the progeny under different conditions of soil and climate.

The waste of seed continues in all the later plantings of the seed produced in the progeny row. If the quantity is sufficient for a regular field planting, a mechanical planter is likely to be used, the seeds being drilled in as many rows as the supply will permit. The seeds thus planted produce under favorable conditions many more plants than it would be advisable to leave to mature. In thinning to the desired stand, 10 or more plants may be destroyed for every one left, depending upon germination, season, and spacing.

The loss thus experienced by the breeder during the three or more years that are required to obtain in quantity seed of his selection is enormous and makes plain the need of having less wasteful methods. Such methods would have a special importance in connection with the breeding of new varieties and would be of even greater practical importance in helping to maintain the uniformity of superior strains by continued selection. Methods that make possible a more rapid increase of select cotton would also be of special value to farmers, who do not, as a rule, practice selection because the process of producing sufficient quantities of pure seed appears to require too much time.

With the need of improved methods in mind, experiments were conducted in 1917 at the United States Experiment Farm at San Antonio, Tex., in cooperation with the Office of Western Irrigation Agriculture, the usual methods of increasing select stocks of cotton being compared with others in which a number of different nurse crops were used. The object of these nurse plantings was to determine whether as good a stand of select cotton can be secured where other kinds of seed supplied the lifting force necessary to break the soil crust as where only select seeds were planted. Could this be done, there obviously would be a material saving of select seed.

To discuss the observations made during the progress of these experiments is the purpose of this bulletin.

PLANTING DISTINCT TYPES OF COTTON.

One way in which seed of a valuable selection may be conserved is by planting it with seed of another variety of cotton which is so different that its seedlings can be distinguished and removed when the stage for thinning has been reached, thus securing the advantages of a heavy rate of seeding without the unnecessary waste of valuable seed. To do this successfully, however, a careful choice of varieties must be made. Obviously, the seedlings of each must possess distinctive leaf characters, so that in thinning only plants of the select strain may be left to grow; otherwise, the purpose of selection would be defeated, since the stock would be contaminated by crossing.

It is doubtful whether two Upland varieties could be found whose seedling characters are different enough to enable the breeder readily to distinguish between them with accuracy; but the fact that other nurse crops can be planted with safety renders unnecessary the selection of another variety of Upland for that purpose.

The danger in planting combinations of varieties of the same general type can be avoided by using varieties of distinct types. The seedlings of Upland and Egyptian cotton, for example, can be distinguished at a glance, thus enabling the breeder to remove either kind with ease, according to which variety he is increasing. The same is true also of Upland and Sea Island seedlings. But it is not possible to mix Egyptian and Sea Island cotton with impunity, as the seedlings of these two types are very difficult to distinguish. Both lack the red spot at the base of the cotyledons which is so characteristic of Upland varieties. Their cotyledons also are of a lighter tint of green than those of most Upland varieties and have a somewhat more distinctly waxy appearance.

Asiatic types of cotton are even more distinct from Upland varieties than is Sea Island or Egyptian, and since they do not cross with American types they may be found useful in nurse planting.

The value of Upland cotton as a nurse crop for Egyptian, or vice versa, was demonstrated in a test at San Antonio. Equal lots of delinted[1] Lone Star (Upland) and Pima (Egyptian) seed were thoroughly mixed and then planted by means of a mechanical planter in a row 264 feet long. When the seedlings were about 6 inches high it was possible to thin to an almost perfect stand of either variety in any section of the row (fig. 1).

PLANTING COTTON SEED WITH BEANS OR PEAS.

A very simple and effective method of avoiding the waste of select cotton seed and at the same time securing the desired crust-lifting force of several seedlings is to plant beans or peas with the cotton seed. This combination appeared especially advantageous at San

[1] See under "Delinting cotton seed for nurse planting" (p. 6).

Antonio, since the peas or beans came up before the cotton planted in the same hills, thus opening the way for the more tender seedlings. All things considered, however, beans seem to be better suited to this purpose than peas, owing to the habit of beans in raising their cotyledons above ground. A strong-growing variety of cowpeas does very well, but in leaving its cotyledons at the depth the seed was planted its lifting force is reduced.

In choosing a variety of beans for planting with cotton seed, the size of the beans should be considered. It appears that a variety of beans having large seeds makes a stronger early growth than one having small seeds; that is, the power to break through a soil crust

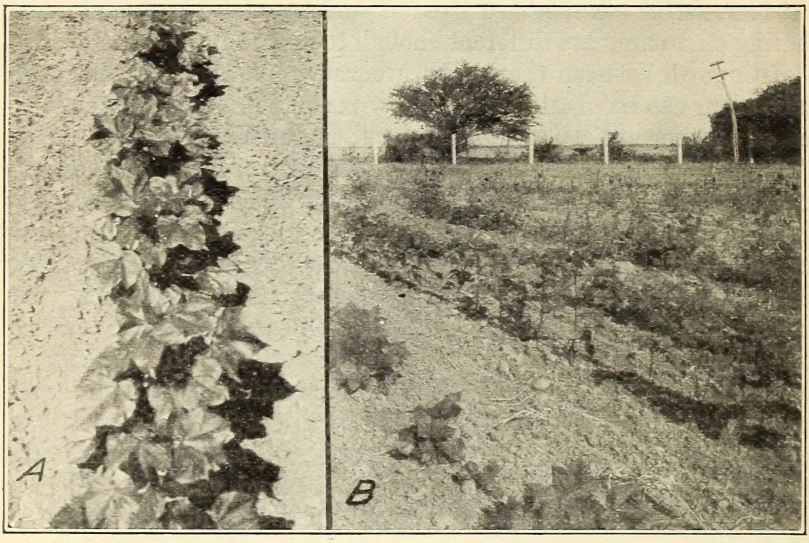

FIG. 1.—Upland (Lone Star) cotton planted as a nurse crop for Egyptian cotton, delinted seed of these varieties having been mixed in equal proportions and planted with a corn planter, using a 6-hole plate: *A*, Section of the row before thinning, when the plants were about 8 inches high, showing the uniform stand obtained; *B*, section of the row after thinning out all the Lone Star plants, showing Egyptian plants standing approximately 18 inches apart. In another section of this row an equally good stand of Lone Star cotton remained after removing all the Egyptian plants. The seedlings of these two types can easily be distinguished. (Photographed July 11, 1917.)

is greater. Thus, for example, the pinto bean was found to be better in this particular than the navy, and the navy better than the soy or tepary. But on the other hand, smaller beans have certain advantages over larger ones, as will be shown when the methods of planting are taken into account.

The early habits of growth of different varieties of beans and peas should also be considered. Large beans, like the pinto, and cowpeas, such as the Black-Eye variety, usually develop broad first leaves. This may be an advantage under some conditions, since the broad leaves would provide a certain protection for the cotton seedlings, but these overspreading leaves are likely at the same time to shade

the cotton seedlings, thus preventing normal growth. This habit of the Black-Eye cowpeas was especially noticeable in the plantings at San Antonio, the growth of the cotton seedlings in the cotton-pea hills being retarded more than in the all-cotton hills or the cotton-bean (tepary) hills. The tepary bean germinates quickly, seems to have sufficient lifting force, and makes a comparatively early growth. The soy bean might do well also, as its size is about what is desired from the standpoint of mechanical planting, but in the tests conducted at San Antonio it did not germinate satisfactorily. In one instance this may have been due to the fact that an inferior variety was the only one available. Later, seed of the Haberlandt variety was obtained and somewhat better results were secured.

Still another point to be given attention in choosing a variety of beans or peas for planting with cotton is the extensiveness of the root systems of the seedlings. This is especially important in so far as it bears on thinning out the bean or pea plants. It was observed that the pinto bean, for example, had developed a network of roots by the time thinning was considered advisable. These roots entangled those of the cotton plants in the same hills, making it necessary to exercise extreme care in thinning, to avoid injury to the cotton plants when the bean plants were pulled up. The cowpeas were not so bad in this particular, nor were the navy beans, but both were worse than the smaller beans, such as the tepary. This danger of injury to the cotton seedlings could, of course, be averted, if the case were such as to justify extreme care, by cutting or pinching off the bean or pea plants instead of pulling them.

RATE OF COMBINING COTTON WITH OTHER SEEDS.

The number of seeds planted in each hill should be varied, of course, according to conditions which are not controllable, such as germination, soil, and climate. Probably the best that can be done is to plant enough seed to provide against poor germination and the possible crusting of the soil. While it may not always be practicable, owing to a limited quantity of seed, to determine the percentage of germination of select cotton, it should be ascertained when conditions permit. It is always practicable to make such determinations with seed of the nurse crops. Knowledge of the viability of these seeds would suggest the rate of planting to employ.

If a maximum increase of a selection is desired, one select seed and three or four beans will be found to give good results. A perfect stand can not, of course, be expected, as it is not likely that all the select seed will germinate. This method of planting was followed at San Antonio (fig. 2) where Tuxtla cotton progenies were planted with pinto beans, and a germination of 90 per cent was obtained, or 99 plants from 110 seeds. If two cotton seeds instead of one had been planted in each hill, it is likely that an even better stand would

have resulted, but in that case plants could have been grown in only 55 instead of 99 hills.

If the breeder were interested in obtaining for comparative study a uniform stand of his progenies rather than maximum increase, two cotton seeds in each hill, with as many nurse seeds as previous determinations on percentage of germination would indicate, should be ample provision against almost any condition that may arise to prevent the emergence of the seedlings. The chances are good that at least one of the two select seeds planted will grow, and one select plant in a hill is all that ordinarily is required, especially where further selection is to be made. The beans, peas, or other cotton seeds planted in the same hill could be depended upon to help the select

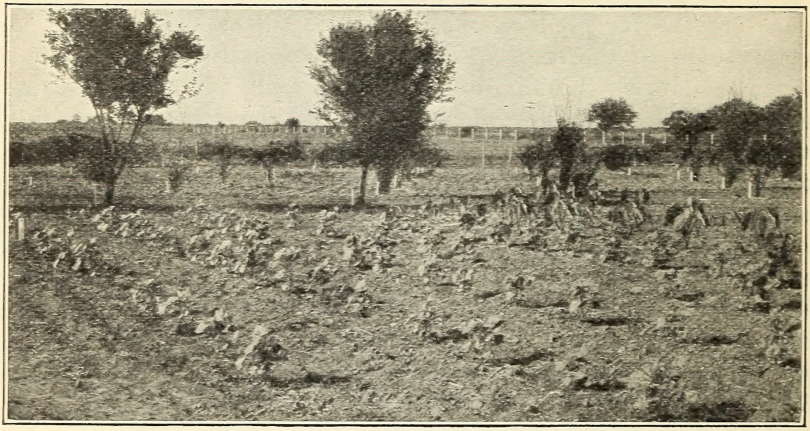

FIG. 2.—Cotton progenies planted with pinto beans. One cotton seed and two or three beans were planted in each hill. In 11 of the 110 hills planted no cotton plants came up, owing to the failure of some seeds to germinate. Had two cotton seeds been planted in each hill, a perfect stand might have been secured; but by so doing only 55 instead of 99 hills could have been grown from the same quantity of seed and the maximum increase would not have been obtained. (Photographed July 3, 1917.)

plant through the soil. If the select seed should have a lower germination than 50 per cent, it would, of course, be advisable to plant accordingly.

The rate of planting to be employed when further increase plantings are made depends upon the seed combination, percentage of germination, and the kind of planter used. This feature will be discussed more in detail in another place.

DELINTING COTTON SEED FOR NURSE PLANTING.

The planting of cotton seeds with beans or peas is greatly facilitated by delinting them. This can be done with ease and little expense by immersing them for about 2 minutes in commercial sulphuric acid. After being delinted they should be washed in running water for at least 10 minutes in order to remove all the acid.

This treatment does not seem to injure the seed and may actually be beneficial, especially as regards germination. Moreover, it was found while treating seed in this manner that during the washing process the seed could be very easily separated according to weight. That it would be advantageous to remove the lighter seed was indicated by the results of several germination tests under field and laboratory conditions. Further experiments along this line are in progress.

Among the advantages to be gained by delinting cotton seeds which have a direct bearing on the present discussion may be mentioned the ease with which they may be handled in hand dropping and the possibility of using a corn planter in making increase plantings. It is a simple matter to take one or two delinted seeds from a bag, but it is more difficult to take only that number when not delinted, as the fuzzy seeds tend to adhere to one another. For the same reason, it is hardly possible to mix thoroughly the fuzzy seeds of two varieties of cotton or of one variety with beans or peas. Furthermore, there probably is no machine that could be used effectively in planting seed mixtures of which fuzzy seed formed a part. But the corn planter, as will be shown, can be used to good advantage when the cotton seeds are delinted.

METHOD OF PLANTING IN HILLS.

Much improvement is possible in the methods of hill planting that are ordinarily practiced. The usual method is for one man to open a shallow hole with a hoe and another man to drop the seeds, the first man covering them with the hoe and compacting the soil about the seed with the hoe or the foot. The chief objection to this method is that considerable care must be exercised to guard against planting the seeds too shallow or too deep. Even under the most favorable circumstances there is usually rather too much variation in this respect. Moreover, it is not always practicable to cover the seeds with moist soil, dry soil often rolling to the seeds before proper covering can be accomplished.

This method is further complicated where nurse plantings are made, though this is not so serious a matter if the cotton seeds have been delinted. It is necessary for the man dropping the seeds to drop the select cotton seed with one hand and the beans or peas with the other. This operation requires a little more time than where cotton alone is being planted, but the gain through the conservation of select seed very likely would more than offset the loss of time involved.

In the experiments at San Antonio the writer found that a simple hand corn-planting device could be used advantageously in planting cotton or cotton-bean or cotton-pea combinations. This planter was designed by the Office of Corn Investigations and was being used in planting some experiment plats with corn on the San Antonio farm when it came to the writer's attention. Briefly it may be described as follows: A wooden strip, 3 inches wide and 36 inches long

(fig. 3), is faced with galvanized iron so shaped as to form two parallel tubes running the entire length of the board. At the top end the tubes are funnel shaped. At the bottom end they empty into a kind of hopper. To this hopper a spring and a lever are attached, by means of which the mouth of the hopper can be opened or closed as desired. At the top of the back of the baseboard a handle is attached. At the bottom there is a flange by which the depth of planting can be regulated.

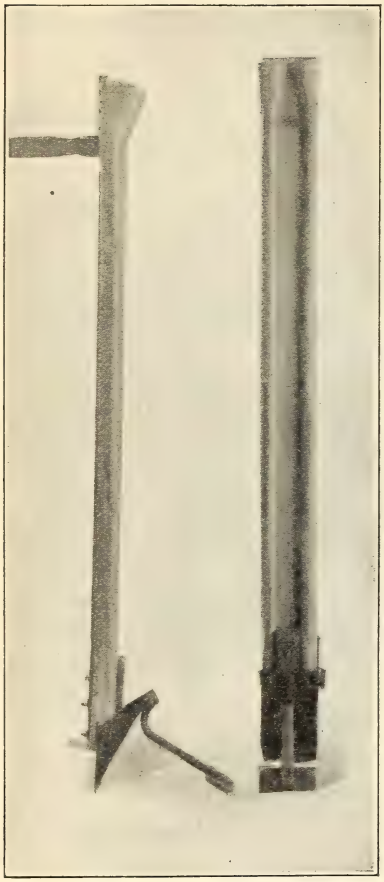

FIG. 3.—Hand corn planter, designed by the Office of Corn Investigations, successfully used at San Antonio in 1917 in planting delinted cotton alone and in combination with peas and beans. The use of a planter of this type appears to have a number of advantages over the usual method of hand-dropping progeny rows. (Photographed July 2, 1917.)

One man can operate the planter very easily. Rapid progress can be made if the seeds to be planted are carried in a pouch attached to each hip, cotton seed in one and beans or peas in the other. One kind of seed can be dropped into one of the tubes and the other kind into the other tube. Then, by thrusting the nose of the planter into the ground at a marked point and giving the planter a forward lifting movement, the seeds may be deposited at a uniform depth in the moist soil. The spring on the hopper closes the latter automatically as the planter is lifted again. As the operator steps forward to plant the next hill he can step lightly on the hill just planted, thus compacting the soil about the seeds, meanwhile dropping more seeds into the tubes, to make ready for further planting.

METHOD OF PLANTING IN DRILLS.

Nurse planting in drills is practicable only with delinted cotton seeds, for reasons already given. With these it becomes a simple operation, since the ordinary corn planter can be used.

Mixtures of Lone Star (Upland) and Pima (Egyptian) cotton, cotton and cowpeas, and cotton and beans were planted successfully with a corn planter at San Antonio in 1917 (figs. 1 and 4). In the

first instance, delinted Lone Star and Pima were mixed in equal proportions and planted through a 6-hole corn plate. The stand obtained made it possible in thinning to leave the plants of either variety about 18 inches apart. In the other rows also it was possible in removing the beans or peas to leave the cotton plants approximately 18 inches apart, though the actual distance varied with the number of holes in the corn plates used. The total number of plants destroyed in thinning these rows varied between 300 and 500 to the row, 264 feet long. Of these, only 7 to 25 per cent were cotton plants, the remainder, 75 to 93 per cent, being peas or beans. This loss of cotton plants was not more than one-fifth (in one case, only a tenth)

FIG. 4.—Cotton planted with a nurse crop by means of a corn planter. Only 7 to 25 per cent of the plants removed from these rows when thinned were cotton plants, 75 to 93 per cent being pea or bean plants. The total number of plants destroyed in each row, 264 feet long, varied from 300 to 500. In the check rows on each side of this plat, which were planted in the usual manner, using an ordinary cotton planter, the number of cotton plants taken out was 453 and 573, respectively. This represents 75 and 80 per cent of the total number of plants in the rows. Not more than one-fifth and in one instance fewer than one-tenth that number of cotton plants were lost where nurse plantings were made. The number of plants in each of the rows shown above approximated 140, the extremes being 120 and 150. The average distance between the plants was 18 inches, the actual distances varying somewhat with the number of holes in the corn plates used. (Photographed July 11, 1917.)

as great as that recorded in check rows planted in the usual manner on each side of the nurse plantings. In thinning these checks, 453 and 573 plants, respectively, were destroyed, representing a loss of 75 and 80 per cent of the total number of plants in the rows.

In using a corn planter for these plantings a nurse crop with seeds about the size of the delinted cotton seed was found to be best suited to the method. Large beans were cracked to some extent even by the large-hole plates, and they would not feed through the plates containing more and therefore smaller holes. The 6-hole plates appeared to feed at about the proper rate in some instances, but it is probable that a 9-hole or 10-hole plate would be preferable if small

beans, such as the tepary or soy, were used as the nurse crop. A 9-hole plate was used in planting a mixture of cotton and soy beans, but owing to the low percentage of germination of the latter the stand secured was rather poor.

In making these plantings the seeds were mixed on the basis ratio of 1 to 1. Some rows were planted with mixtures containing less than half cotton, but none containing more than that amount. Where a 1 to 2 mixture was used the stand of cotton was not as good as desired. However, the cotton used had a relatively low percentage of germination. With a variety giving a better germination the 1 to 2 mixture might prove to be satisfactory. Here, again, the rate of mixing must be determined in each instance on the basis of the percentage germination of the different seeds used and the size of the corn plates used in planting.

Under specially favorable conditions it may not be necessary to plant a nurse crop in order to conserve select cotton seed. Mr. D. A. Saunders, of the Bureau of Plant Industry, obtained very satisfactory stands in 1917 at Greenville, Tex., by planting delinted Lone Star cotton seed alone with both a 4-hole and a 5-hole corn plate. The seeds were dropped 12 to 18 inches apart, and one or two plants grew in each hill, as the soil conditions were favorable to good germination. As no thinning was necessary, a maximum increase of seed resulted. But under most conditions the chances of obtaining a good stand would be greater were a nurse crop used.

ADVANTAGES IN NURSE PLANTING.

The chief advantages to be gained by using a nurse crop in increasing select cotton seed are the saving in select seed and the resultant possibility of more rapidly increasing the supply of such seed.

The saving involved in planting seed mixtures in hills, as suggested herein, might easily amount to 30 or 60 per cent where three to six seeds are planted in each hill. In subsequent increase plantings the saving might be even greater, as most of the plants removed in thinning would be nurse plants and not select cotton plants.

The following hypothetical example will serve to illustrate these advantages of nurse planting: Assuming that from a select plant there has been gathered a quarter of a pound of seed cotton containing 600 seeds and that all these seeds are to be planted in a progeny row, the number of hills that may be planted will vary between 100 and 600, according to whether the seeds planted in each hill number six, five, four, three, two, or one. Assuming further that only one plant in a hill is to be left to mature, and that each will produce, as did the parent plant, 600 seeds, then on the basis of 3,600 seeds to the pound, the increase in seed will vary from 17 to 100 pounds, depending on the rate of seeding used. (Table I.)

TABLE I.—*Comparative seed increase of cotton when planted in progeny rows, the number of seeds in a hill being varied from one to six.*

Rate of planting.	Number of hills.	Seed produced.	Rate of planting.	Number of hills.	Seed produced.
		Pounds.			*Pounds.*
6 seeds to hill	100	17	3 seeds to hill	200	33
5 seeds to hill	120	20	2 seeds to hill	300	50
4 seeds to hill	150	25	1 seed to hill	600	100

In carrying the example farther, it is sufficient to compare only the 4-seed and 2-seed rates. In the one case, 600 cotton seeds might be planted four in a hill in the usual manner, making a total of 150 hills. In the other, 600 cotton seeds, if nurse planted two in a hill, would give 300 hills in all. After thinning out the surplus plants in each hill, there would remain, therefore, 150 cotton plants in the first instance and twice that number, or 300, in the second. The total production of seed from the 150 plants would be 25 pounds, as compared with 50 pounds from the 300 plants, a gain of 100 per cent. If nurse planting were practiced the second year, the gain would become 400 per cent. The 25 pounds of seed produced by the progeny row planted in the usual way would, for example, plant 1 acre if planted with a cotton planter, while the 50 pounds from the nurse-planted progeny row would plant 4 acres if delinted, mixed in equal proportion with beans or peas, and planted with a corn planter. By carrying this procedure through the third year, as shown in Table II, it would be possible to plant in the fourth year only 3,040 acres with the stock of seed increased in the usual manner, while with the nurse-planted stock it would be possible to plant 16 times as much, or 48,646 acres.

TABLE II.—*Comparative increase of seed when select cotton is planted in the usual way and under nurse planting.*

Method of planting.	First year (progeny row).			Plantings at the rate of 25 pounds per acre.				
				Second year.		Third year.		Fourth year.
	Cotton seeds in a hill.	Number of hills.	Seed produced.	Area planted.	Seed produced.	Area planted.	Seed produced.	Area planted.
			Pounds.	*Acres.*	*Pounds.*	*Acres.*	*Pounds.*	*Acres.*
Usual	4	150	25	1	1,382	55	76,010	3,040
Nurse (half cotton and half nurse crop)	2	300	50	4	5,528	440	508,080	48,646

It is reasonable to believe, therefore, that at least one and probably two or three years could be gained in increasing select cotton seed if the method of nurse planting herein described were followed. Such a gain would more than repay the extra time and labor expended, as well as the cost of the beans or peas. This would often be true even if the saving of seed were much less, for there is no basis for estimating the value of a particularly desirable selection of cotton.

The saving of seed through nurse planting makes it possible also to duplicate or triplicate the planting in other fields. Such a precaution would provide against the total loss of a selection because of hail, floods, or other factors. Duplicate or triplicate plantings also afford an opportunity to study the behavior of the selection under a wider range of soil and climatic conditions.

While this method of nurse planting seems to be especially well suited to the needs of breeders, it is possible also that such a method would prove advantageous to the farmer who pays a high price for a small quantity of select seed. It appears that he could thus increase his seed to an extent that would enable him to plant his entire farm one or two years sooner than if he employed the usual method of increase. In order to avoid all danger of crossing, however, it probably would be best for farmers to use beans or peas as a nurse crop instead of different types of cotton.

A way in which nurse planting small stocks of cotton seed could be of immediate practical importance is in connection with the congressional distribution of seed. The method of distribution is, first, to send out quart packages of superior seed and follow these the second year with half-bushel lots to those farmers who show by their care of the quart samples and their report on the behavior of the varieties the proper interest in establishing and maintaining a seed supply. By nurse planting his half bushel of seed a farmer could obtain a much greater increase of the variety than would be possible by the usual methods of planting.

SUMMARY.

The present methods of increasing select cotton are wasteful. The number of seeds planted far exceeds the number of plants that can be left to mature. Usually 50 to 75 per cent of the seedlings are destroyed at the time of thinning.

The method herein suggested substitutes other seeds, those of a distinct type of cotton or of beans or peas, for those select cotton seeds that produce surplus plants. Thus, in thinning, the number of select seedlings that have to be destroyed is greatly reduced, most of the surplus plants representing other seeds (beans or peas). These plants are as effective as the select plants in breaking through a soil crust, which is the chief purpose of planting at a high rate.

At San Antonio, Tex., where experiments were conducted, successful plantings of seed mixtures were made by improved methods in hills and in drills with both hand and mechanical corn planters. The use of corn planters for planting cotton seed was made possible by delinting the cotton with sulphuric acid.

By utilizing this method of nurse planting in increasing cotton selections, it is believed that a gain of at least one year and probably three years in time can be effected, as 30 to 60 per cent more land may be planted each year with select seed than is possible by present methods.

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